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(71) Applicant *(for all designated States except US)*: **TELIA AB** [SE/SE]; Mårbackagatan 11, S-123 86 Farsta (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **AHLARD, David** [SE/SE]; Hållsätrabacken 37, S-127 37 Skärholmen (SE). **BERGKVIST, Joakim** [SE/SE]; Barksv 12, S-170 73 Solna (SE). **CSELÉNY, Istvan** [SE/SE]; Tvilingarnas g. 317, 1tr, S-136 63 Haninge (SE).

(74) Agent: **PRAGSTEN, Rolf**; Telia Research AB, Vitsandsgatan 9, S-123 86 Farsta (SE).

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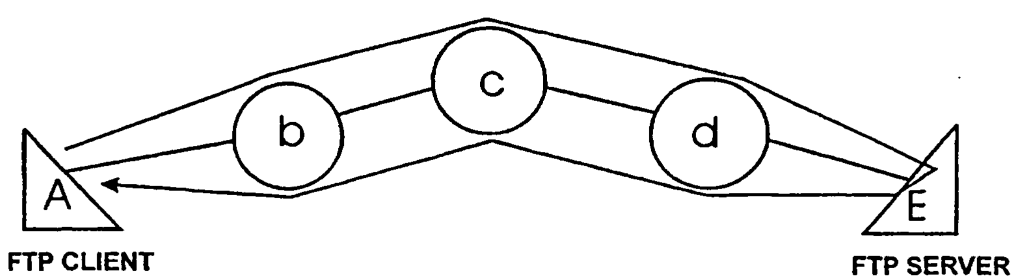

(57) Abstract: The invention provides a data transmission network having a number of network nodes, which include routers and end terminals, in which end-to-end data transmission paths are established between end terminals using a hop-by-hop resource reservation signalling protocol (called a RING - Reservation pING protocol) and in which an Internet Control and Management Protocol (ICMP) is used for message transportation. The network uses ICMP ECHO and ICMP REPLY messages (PING) for message transportation. The IP flow, specified in the reservation message, is provided with a hard QoS in the RING-aware part of the network and a soft QoS in the DiffServ capable domains.

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A METHOD FOR ESTABLISHING END-TO-END DATA TRANSMISSION PATHS USING THE ICMP BASED HOP-BY-HOP RESOURCE RESERVATION SIGNALLING PROTOCOL

The invention relates to a data transmission network in which a hop-by-hop resource reservation signalling protocol is used to establish data paths, and in which an Internet Control and Management Protocol (ICMP) is used for message transportation, a method for establishing end-to-end data transmission paths, and IP routers and end user equipments adapted to implement the hop-by-hop resource reservation signalling protocol.

Differentiated Services (DiffServ) proposed by the Internet Engineering Task Force (IETF) provide a means of specifying specific per hop behaviours for different types of traffic, as indicated by the ToS (Type of Service) field in an Internet Protocol (IP) header. One such 'class' is expedited forwarding which implies that the amount of incoming resources must not exceed the available resources. For such an arrangement to be feasible, it is necessary to have some form of CAC (Connection Admission Control), which means some kind of signalling.

In essence, the main purpose of CAC is to reject incoming connection requests if the available bandwidth in a network node is less than the smallest element of a downgrading vector, but otherwise accept the connection request and allocate bandwidth according to the largest element of the downgrading vector that fits into the disposable capacity. The down grading vector represents the discrete bandwidth downgrading steps for an application.

If downgrading occurs, a reservation tear message is sent backwards to the up-stream nodes to initiate release of excess reservation resulting from the downgrading. The tear message is also propagated along the backward path. The fact that the network downgrades to those quality levels that correspond to rational settings for the application, does not mean that the user will accept the established connection.

If downgrading happens inside the network, the user will decide whether, or not, the quality level of the established service is acceptable.

A hop-by-hop resource reservation signalling protocol provides a robust and simple solution to the need for some kind of signalling. There are, however, a number of issues that must be addressed in respect of such a protocol, namely:

(Fel! Okänt växelargument.) scalability: the amount of resources in terms of the required states, or generated traffic, in central network nodes;

(Fel! Okänt växelargument.) transparency: the ability to use the protocol together with existing IP protocols and devices;

(Fel! Okänt växelargument.) penetration: the ability to gradually introduce the protocol into an Internet platform;

(Fel! Okänt växelargument.) robustness: the ability to handle network failures, for example, loss of messages and route changes; and

(Fel! Okänt växelargument.) efficiency: the required amount of network and processing capacity.

It is an object of the present invention to provide a robust and simple solution to the problems, referred to above, through use of a data transmission network in which a hop-by-hop resource reservation signalling protocol is used to establish data paths, and in which an Internet Control and Management Protocol (ICMP) is used for message transportation.

It is another object of the present invention to provide a method for establishing end-to-end data transmission paths using the ICMP based hop-by-hop resource reservation signalling protocol.

It is further object of the present invention to provide IP routers and end terminals which are adapted to implement the ICMP based hop-by-hop resource reservation signalling protocol.

According to one aspect of the present invention, there is provided, a data transmission network having a number of network nodes, which include routers and end terminals, said network being adapted to establish end-to-end data transmission paths between end terminals, characterised in that said network is adapted to establish said data transmission paths using a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

The hop-by-hop resource reservation signalling protocol may be a RING - Reservation pING protocol.

The data transmission network may be adapted to use ICMP ECHO and ICMP REPLY messages (PING) for message transportation.

The data transmission network may include means for specifying per hop behaviour for different types of traffic, and the different types of traffic may be indicated by a Type of Service (ToS) field in an IP header of an IP data packet. The means for specifying per hop behaviour for different types of traffic may be provided by a Differentiated Services (DiffServ) mechanism.

The hop-by-hop resource reservation signalling protocol may be adapted to provide an IP flow specified in a resource reservation message with a hard Quality of Service (QoS) in RING-aware parts of the network and a soft QoS in DiffServ capable network domains.

At least some of said network nodes may be passive and be adapted to set output flags and forward RING messages.

The routers may be IP routers and the IP routers may be adapted to use said resource reservation signalling protocol.

The end terminals may be adapted to use said resource reservation signalling protocol.

The data transmission network may include an IP platform and the IP routers may be adapted for use in said IP platform for end-to-end resource reservation for IP services.

The data transmission network may be adapted to reserve bandwidth both for a forward path and a backward path between end terminals, even if said paths are different paths.

The data transmission network may include an Intelligent Resource Management Architecture (IRMA) and said routers may be IRMA routers that are adapted to use said resource reservation signalling protocol.

The data transmission network may be adapted to use a File Transfer Protocol (FTP) for downloading a file from a first end terminal to a second end terminal. The first end terminal may be a FTP server, and the second end terminal may be a FTP client terminal.

According to another aspect of the present invention, there is provided, in a data transmission network having a number of network nodes and a plurality of end terminals, said network being adapted to establish end-to-end data transmission paths between end terminals, a method for establishing said end-to-end data transmission paths, characterised by establishing said data transmission paths using a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

The method may be characterised by said hop-by-hop resource reservation signalling protocol being a RING - Reservation pING protocol.

The method may be characterised by using ICMP ECHO and ICMP REPLY messages (PING) for message transportation.

The method may be characterised by specifying per hop behaviour for different types of traffic. This method may be further characterised by indicating said different types of traffic by a Type of Service (ToS) field in an IP header of an IP data packet.

The method may be characterised by using a Differentiated Services (DiffServ) mechanism for specifying per hop behaviour for different types of traffic. This method may be further characterised by providing an IP flow, specified in a resource reservation message, with a hard Quality of Service (QoS) in RING-aware parts of said network and a soft QoS in DiffServ capable network domains.

The method may be characterised by said resource reservation signalling protocol generating a 'ping' message containing a signalling message with (a) a source-destination address pair and transport protocol id; (b) user ID and authentication credential (optional); and (c) desired forward and reverse QoS descriptor. This method may be further characterised by said 'ping' message propagating hop-by-hop through said network and by each RING-aware network node performing a CAC lookup to check whether a new flow can be admitted into a hard QoS class.

The method may be characterised by said RING-aware network node, in the event that the new flow can be admitted into the hard QoS class, registering the reservation for the new flow.

The method may be characterised by said RING-aware network node being an access node, and by said access node creating a mechanism for regulating

(policing) the assigned resource.

The method may be characterised by said RING-aware network node, in the event that the new flow can not be admitted into the hard QoS class, setting a NACK flag in the reservation message and by forwarding the NACK flag to the next hop.

The method may be characterised by a receiving terminal echoing a received 'ping' message along a reverse path to an end terminal that initiated said message, and by reserving resources along said reverse path.

The method may be characterised by said receiving terminal being a RING-aware terminal, and by said RING-aware terminal processing the received message.

The method may be characterised by said initiating terminal either repeating, downgrading, or revoking, the last request, in the event that a NACK flag has been set, or a reservation message is lost.

The method may be characterised by said network nodes releasing resource reservations for inactive flows after a predetermined period of time.

According to another aspect of the present invention, there is provided, a router for a data transmission network, characterised in that said router is adapted to use a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation. The router may be an IP router and the IP router may be adapted for use in an IP platform for end-to-end resource reservation for IP services. The router may be an IRMA router, adapted for use in an Intelligent Resource Management Architecture.

According to another aspect of the present invention, there is provided, an end terminal for a data transmission network, characterised in that said end terminal

is adapted to use a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

According to another aspect of the present invention, there is provided, a data transmission system, characterised in that said system includes a data transmission network as outlined in preceding paragraphs, or uses a method as outlined in preceding paragraphs

According to another aspect of the present invention, there is provided, a data transmission system, as outlined in the preceding paragraph, characterised in that said network includes a router, or an end terminal, as outlined in preceding paragraph.

The foregoing and other features of the present invention will be better understood from the following description with reference to the accompanying drawings, in which:

Figure 1 diagrammatically illustrates, in the form of a block diagram, resource reservation in a data transmission network using a RING protocol.

A glossary of the abbreviations used in this patent specification is set out below to facilitate an understanding of the present invention.

ATM:	Asynchronous Transfer Mode
CAC:	Connection Admission Control
DiffServ:	Differentiated Services
FTP:	File Transfer Protocol
ICMP:	Internet Control and Management Protocol

id: Transport Protocol Identification

ID: User Identification

IETF: Internet Engineering Task Force

IP: Internet Protocol

IRMA: Intelligent Router Management Architecture

NACK: Negative Acknowledgement

QoS: Quality of Service

RSVP: Resource Reservation Protocol

ToS: Type of Service

It will be seen from the subsequent description that the data transmission network of the present invention uses an ICMP based hop-by-hop resource reservation protocol for differentiated services and that the use of ICMP echo messages for transport reservation messages is unique and ensures transparency by virtually every existing network component

A resource reservation signalling protocol of the present invention, called 'RING - Reservation pING', relies on the existing ICMP ECHO and ECHO REPLY messages (i.e. PING) for transport. The objective of using this protocol is to provide an IP flow, specified in a reservation message, with a hard QoS (Quality of Service) in the RING-aware part of the network and a soft QoS in the DiffServ capable domains.

In accordance with the present invention, a 'ping' message is generated which contains the signalling message with:

-. a source-destination address pair and transport protocol id;

-. user ID and authentication credential (optional); and

-. desired forward and reverse QoS descriptor (currently only bitrate).

The 'ping' message propagates hop-by-hop through the network, i.e. as an ordinary 'ping', and each RING-aware network node performs a CAC lookup, i.e. the CAC checks whether, or not, the new flow can be admitted into the hard QoS class.

If the new flow can be admitted into the hard QoS class, the network node registers the reservation for the flow and, if it is an access node, creates a mechanism for regulating (policing) the assigned resource.

If the new flow can not be admitted into the hard QoS class, the network node sets the NACK flag in the reservation message and forwards it to the next hop.

The receiving terminal echoes the message, i.e. as if it were an ordinary 'ping' message, or processes the message, if it is RING-aware terminal, and resources are bound (reserved) in the same way along the reverse path.

If the node sets a NACK flag, or the reservation message is lost, the initiating terminal is adapted to either repeat, downgrade, or revoke the last request. After a predetermined time, i.e. when a certain timeout has elapsed, the network nodes release the resource reservations for inactive flows.

In practice, apart form the end-terminals, all of the network nodes are passive, i.e. only the two end terminals talk to each other, the intervening nodes merely set the output flags (i.e. NACK, cause of failure, etc...) and forward the RING

message.

Consideration will now be given, by way of example, to the date transmission network which is diagrammatically illustrated, in the form of a block diagram, in Figure 1 of the accompanying drawings. As illustrated in Figure 1, this network includes three network nodes, 'b'., 'c' and 'd', situated between two end terminals 'A' and 'E'.

In considering this example, it will be assumed that:

-. the end terminals 'A' and 'E' are respectively a terminal for a FTP Client and a FTP Server;

-. the network nodes 'b' and 'd' are access nodes, respectively for the end terminals 'A' and 'E'; and

-. the network node 'c' represents a potential bottleneck node in the transmission network.

In the event that the FTP Client wishes to reserve resources for a file download from the FTP Server 'E' to the end terminal 'A', the end terminal 'A' compiles a signalling message requesting resources for a backward path from the FTP Server 'E' to the end terminal 'A'.

The signalling message propagates hop-by-hop, similar to a normal PING, but since no resources are being requested in the forward direction, no action is taken.

When the message reaches the destination, i.e. the FTP Server 'E', it is echoed as an ICMP/ECHO REPLY message and starts to propagate in the reverse direction towards end terminal 'A'. Each of the network nodes, 'b', 'c' and 'd', now check, in turn, for available resources. Since the 'd' node is an access node, it also

creates a resource entry for regulating (policing), and accounting for, the assigned resource (i.e. bandwidth).

When a RING message arrives back to end terminal 'A', the terminal checks the NACK flag to see whether the resource reservation was successful.

In addition, the end terminal 'A' can 'RING-up' the end terminal 'E' in order to reserve a flow with guaranteed bandwidth for the FTP session.

In practice, bandwidth can be reserved both for the forward path and the backward path between end terminals 'A' and 'E', even if these paths are different paths, which is very beneficial in the case of a symmetrical session, for example, IP telephony.

The resource reservation signalling protocol 'RING - Reservation pING', can be implemented in IP routers and end-terminals. Furthermore, such IP routers can be used, for example, in IP platforms for end-to-end resource reservation for IP services.

In the case of large IP networks, for example, the Internet, RING-aware routers can be introduced in the bottleneck sections of a network (for example, an access network, a transatlantic link, etc..) in order to ensure that messages with a hard QoS are available for mission critical, or demanding, applications.

Other QoS mechanisms, for example, DiffServ and IntServ, running on far-end terminals and in the rest of the network, can either cooperate with RING-aware routers, or merely transmit the RING messages transparently.

It will be seen from the foregoing description that:

- use of ICMP echo messages for the transmission of reservation messages is unique and ensures transparency by virtually every existing network

component; and

-. the RING protocol is simpler, and scales better, than common resource reservation protocols, for example, RSVP, for uni-cast and sender initiated multi-cast sessions.

The main technical advantages to be gained from the present invention are:

(Fel! Okänt växelargument.) Scalability

The processing of the RING protocol requires no signalling states, unlike RSVP which has PATH and RESV states.

(Fel! Okänt växelargument.) Flow States

Storage of the reserved amount of resource for a specific flow is much simpler than is the case with other protocols, for example, RSVP.

(Fel! Okänt växelargument.) Passive Nodes

Network nodes merely forward the RING messages and do not have to generate new messages.

(Fel! Okänt växelargument.) Transparency

The vast majority of current IP-capable network devices support 'ping' and will, therefore, work with the RING protocol.

(Fel! Okänt växelargument.) Penetration

The RING protocol can co-operate with other IP QoS mechanisms such as DiffServ, or IntServ, and can, therefore, be gradually introduced into a

network.

(Fel! Okänt växelargument.) Robustness

Unlike RSVP, the reservation mechanism of the present invention is not based on a large number of permanent states in network nodes, with the result that unneeded reservations are timed out and new reservations can be made after a failures, or changes (e.g. rerouting), in the network.

(Fel! Okänt växelargument.) Efficiency and Simplicity

The RING protocol is relatively simple to implement in IP routers in that it:

-. requires only a small amount of memory in the nodes;

-. uses only two simple protocol primitives; and

-. is based on 'passive nodes'

(Fel! Okänt växelargument.) Own Reservation Protocol

It can be beneficial for network operator to have an own reservation protocol, which does not interfere with, or more particularly, cooperates well with, other QoS mechanisms in the network, for example, DiffServ, and which effects resource reservation where required by the operator.

The present invention is adapted for use in a number of applications, for example, an IP router, in which the resource reservation signalling protocol of the present invention has been implemented, may be used together with the RING protocol to allocate resources for the flows of IP applications, such as RealVideo, FTP, and Netscape.

The resource reservation signalling protocol of the present invention may also find application a router for an Intelligent Resource Management Architecture (IRMA). The IRMA router could be used, for example, to identifying the requirements on QoS support in a network from the perspective of multimedia applications. In addition, an IRMA router, utilising the RING protocol, may be used to control QoS during group access of residential users. Furthermore, end-to-end resource management, billing and customer management issues for IP platforms, may also be based on an IRMA router which utilises the resource reservation signalling protocol of the present invention.

CLAIMS

1. A data transmission network having a number of network nodes, which include routers and end terminals, said network being adapted to establish end-to-end data transmission paths between end terminals, characterised in that said network is adapted to establish said data transmission paths using a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

2. A data transmission network, as claimed in claim 1, characterised in that said hop-by-hop resource reservation signalling protocol is a RING - Reservation pING protocol.

3. A data transmission network, as claimed in claim 1, or claim 2, characterised in that said network is adapted to use ICMP ECHO and ICMP REPLY messages (PING) for message transportation.

4. A data transmission network, as claimed in any preceding claim, characterised in that said network includes means for specifying per hop behaviour for different types of traffic.

5. A data transmission network, as claimed in claim 4, characterised in that said different types of traffic are indicated by a Type of Service (ToS) field in an IP header of an IP data packet.

6. A data transmission network, as claimed in claim 4, or claim 5, characterised in that said means for specifying per hop behaviour for different types of traffic are provided by a Differentiated Services (DiffServ) mechanism.

7. A data transmission network, as claimed in claim 6, characterised in that said hop-by-hop resource reservation signalling protocol is adapted to provide an IP

flow specified in a resource reservation message with a hard Quality of Service (QoS) in RING-aware parts of the network and a soft QoS in DiffServ capable network domains.

8. A data transmission network, as claimed in any preceding claim, characterised in that at least some of said network nodes are passive and are adapted to set output flags and forward RING messages.

9. A data transmission network, as claimed in any preceding claim, characterised in that said routers are IP routers, and in that said IP routers are adapted to use said resource reservation signalling protocol.

10. A data transmission network, as claimed in any preceding claim, characterised in that said end terminals are adapted to use said resource reservation signalling protocol.

11. A data transmission network, as claimed in claim 9, or claim 10, characterised in that said network includes an IP platform, said IP routers being adapted for use in said IP platform for end-to-end resource reservation for IP services.

12. A data transmission network, as claimed in any preceding claim, characterised in that said network is adapted to reserve bandwidth both for a forward path and a backward path between end terminals, even if said paths are different paths.

13. A data transmission network, as claimed in any preceding claim, characterised in that said network includes an Intelligent Resource Management Architecture (IRMA) and in that said routers are IRMA routers that are adapted to use said resource reservation signalling protocol.

14. A data transmission network, as claimed in any preceding claims,

characterised in that said network is adapted to use a File Transfer Protocol (FTP) for downloading a file from a first end terminal to a second end terminal, in that said first end terminal is a FTP server, and in that said second end terminal is a FTP client terminal.

15. In a data transmission network having a number of network nodes and a plurality of end terminals, said network being adapted to establish end-to-end data transmission paths between end terminals, a method for establishing said end-to-end data transmission paths, characterised by establishing said data transmission paths using a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

16. A method as claimed in claim 15, characterised by said hop-by-hop resource reservation signalling protocol being a RING - Reservation pING protocol.

17. A method, as claimed in claim 15, or claim 16, characterised by using ICMP ECHO and ICMP REPLY messages (PING) for message transportation.

18. A method, as claimed in any of claims 15 to 17, characterised by specifying per hop behaviour for different types of traffic.

19. A method, as claimed in claim 18, characterised by indicating said different types of traffic by a Type of Service (ToS) field in an IP header of an IP data packet.

20. A method, as claimed in claim 18, or claim 19, characterised by using a Differentiated Services (DiffServ) mechanism for specifying per hop behaviour for different types of traffic.

21. A method, as claimed in claim 20, characterised by providing an IP flow, specified in a resource reservation message, with a hard Quality of Service (QoS) in RING-aware parts of said network and a soft QoS in DiffServ capable network domains.

22. A method, as claimed in any of claims 15 to 21, characterised by said resource reservation signalling protocol generating a 'ping' message containing a signalling message with:

(-) a source-destination address pair and transport protocol id;

(-) user ID and authentication credential (optional); and

(-) desired forward and reverse QoS descriptor.

23. A method, as claimed in claim 22, characterised by said 'ping' message propagating hop-by-hop through said network and by each RING-aware network node performing a CAC lookup to check whether a new flow can be admitted into a hard QoS class.

24. A method, as claim 23, characterised by said RING-aware network node, in the event that the new flow can be admitted into the hard QoS class, registering the reservation for the new flow.

25. A method, as claimed in claim 24, characterised by said RING-aware network node being an access node, and by said access node creating a mechanism for regulating (policing) the assigned resource.

26. A method, as claim 23, characterised by said RING-aware network node, in the event that the new flow can not be admitted into the hard QoS class, setting a NACK flag in the reservation message and by forwarding the NACK flag to the next hop.

27. A method, as claimed in any of claims 22 to 26, characterised by a receiving terminal echoing a received 'ping' message along a reverse path to an end terminal that initiated said message, and by reserving resources along said reverse path.

28. A method, as claimed in claim 27, characterised by said receiving terminal being a RING-aware terminal, and by said RING-aware terminal processing the received message.

29. A method, as claimed in any of claims 27, or claim 28, characterised by said initiating terminal either repeating, downgrading, or revoking, the last request, in the event that a NACK flag has been set, or a reservation message is lost.

30. A method, as claimed in any of claims 15 to 29, characterised by said network nodes releasing resource reservations for inactive flows after a predetermined period of time.

31. A router for a data transmission network, characterised in that said router is adapted to use a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

32. A router, as claimed in claim 31, characterised in that said router is an IP router.

33. A router, as claimed in claim 32, characterised in that said IP router is adapted for use in an IP platform for end-to-end resource reservation for IP services.

34. A router, as claimed in claim 31, characterised in that said router is an IRMA router, adapted for use in an Intelligent Resource Management Architecture.

35. An end terminal for a data transmission network, characterised in that said end terminal is adapted to use a hop-by-hop resource reservation signalling protocol including an Internet Control and Management Protocol (ICMP) for message transportation.

36. A data transmission system, characterised in that said system includes a data transmission network as claimed in any of claims 1 to 14, or uses a method as claimed in any of claims 15 to 30.

37. A data transmission system, as claimed in claim in claim 36, characterised in that said network includes a router as claimed in any of claims 31 to 34, or an end terminal as claimed in claim 35.

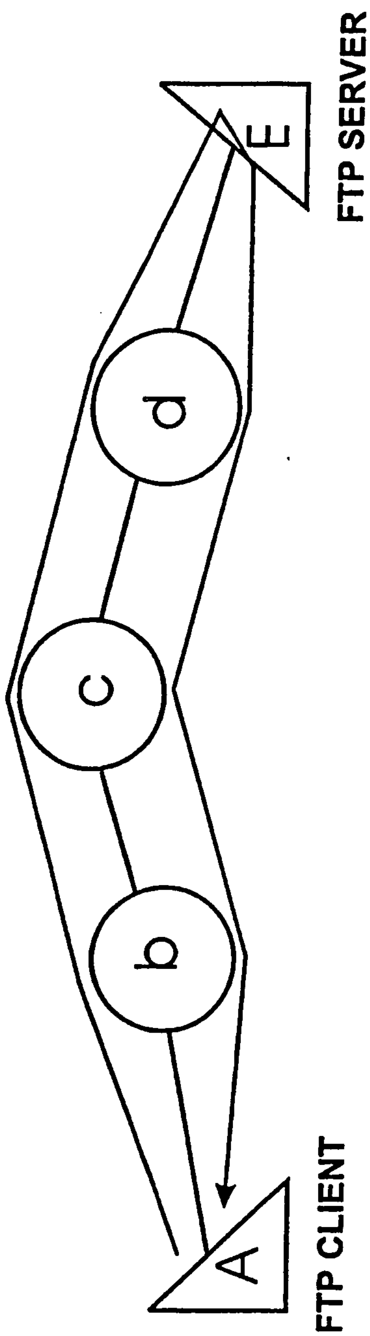

FIGURE 1